# ADVANCED ATSR WORLD FIRE ATLAS BASED ON SWIR CHANNEL: 21 YEARS OF FIRE MONITORING


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## ABSTRACT

A new fire detection algorithm ALGO3, has been tested and validated for ATSR-1/-2 and AATSR. This extends the ATSR World Fire Atlas (WFA) to 21 years of global night-time fire series (Arino, Casadio and Serpe, 2011). Based on detection of the ATSRs 1.6 µm SWIR band radiances during night-time observations, ALGO3 fully extends the ATSR-WFA time series back to 1991 using the ATSR-1 measurements. But the ALGO3 can only be used outside the South Atlantic Anomaly (SAA) zone of influence (Casadio and Arino, 2011). The detection capability of ALGO3 has been estimated in certain case to be an order of magnitude more efficient than the 3.7 µm ATSR-WFA algorithms (ALGO1/2). The validation has been performed comparing ALGO3 products with respect to the ones generates by MODIS-Terra. Global night-time fire trends have been evaluated by inspecting the time series of hot spots aggregated at Continental and Country scale. The Advanced ATSR-WFA products covering 21 years of global night-time fire monitoring, generated applying ALGO3, will be soon freely available for the scientific community on ESA DUE World Fire Atlas web page.


## 1. INTRODUCTION

During his long history the ATSR-WFA demonstrated its usefulness in many research areas. The basic ALGO1 and ALGO2 approaches have been recognised to be extremely efficient and related results satisfactorily accurate for monthly statistical analysis. They consist in the detection of ATSR 3.7µm night-time brightness temperatures exceeding 312 K and 308 K respectively. One of the ALGO1/2 drawbacks is the dependence of the 3.7 µm brightness temperature values from the background temperature. In fact, being the total radiance that reaches the satellite instrument the combination of the contributions from both burning and non-burning fractions of the ground pixel, a fixed threshold for the hot spot detection cannot account for seasonal variations of the contributing background. ALGO3 overcomes this problem considering the 1.6 µm band behaviour during night-time observations. At NIR wavelengths the contribution of background to night-time radiation is negligible (far below the noise level of the ATSR detectors) while it can be demonstrated that a useful signal is detected for active fires even for very small fire fractions. The ALGO3 method is based on the detection of 1.6 µm band reflectance values larger than a fixed threshold (=0.09%) which is twice the detector noise level. The radiometric stability of the ATSR instrument series ensures the consistency of the detection capability for long time periods [2]. This new algorithm, ALGO3, extends the ATSR-WFA to 21 years of global night-time fire series.

## 2. ADVANCED ATSR-WFA TEST SITES

In order to validate ALGO3 eight test sites have been considered: Australia, Central Africa, West Africa, South Europe, India, South-East Asia, Central America, Borneo. As shown in Fig.1, mask has been defined in order to exclude the South Atlantic Anomaly [3] from the ALGO3 analysis. The red and the grey circles indicate respectively the positions of gas flares sites with radius proportional to the total number of hot spots detected and volcanoes know to be active during the last 10 years [2].


*Proc. 'ESA Living Planet Symposium 2013', Edinburgh, UK*
*9–13 September 2013 (ESA SP-722, December 2013)*

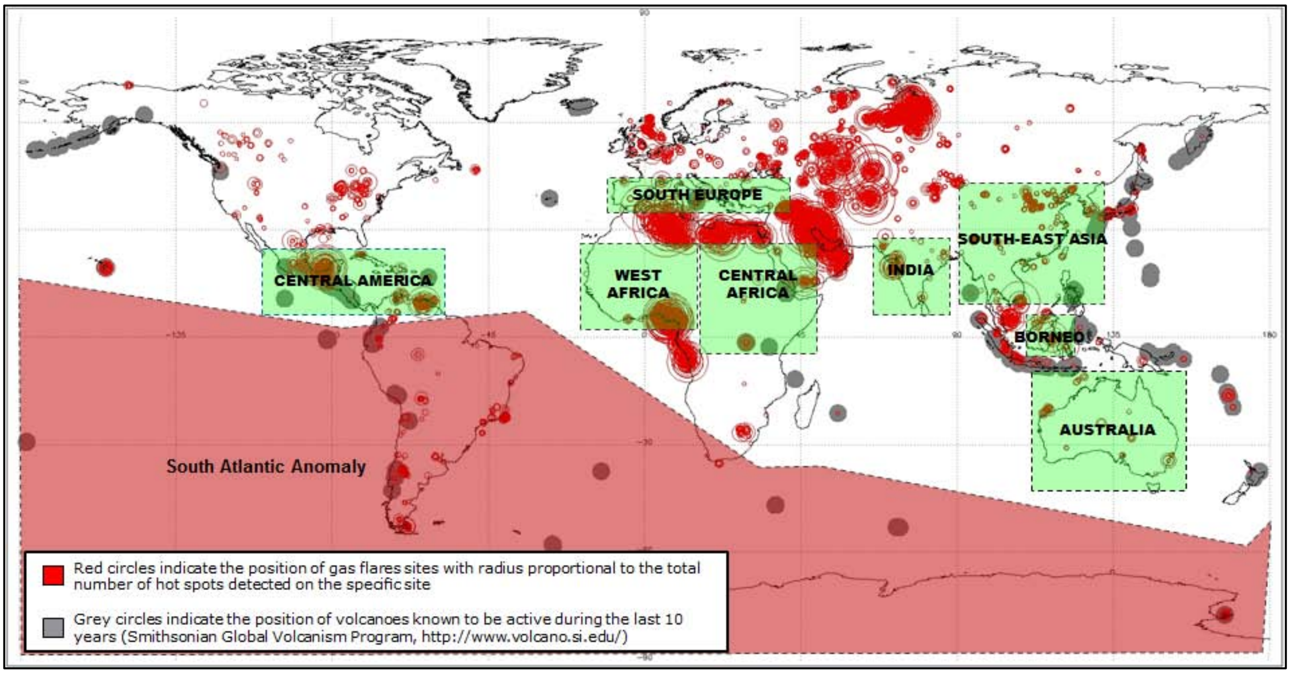


*Figure 1: The green rectangles represent the regions of interest considered in the analysis, the red circles indicate the positions of gas flares sites with radius proportional to the total number of hot spots detected and the grey circles indicate volcanoes know to be active during the last 10 years.*

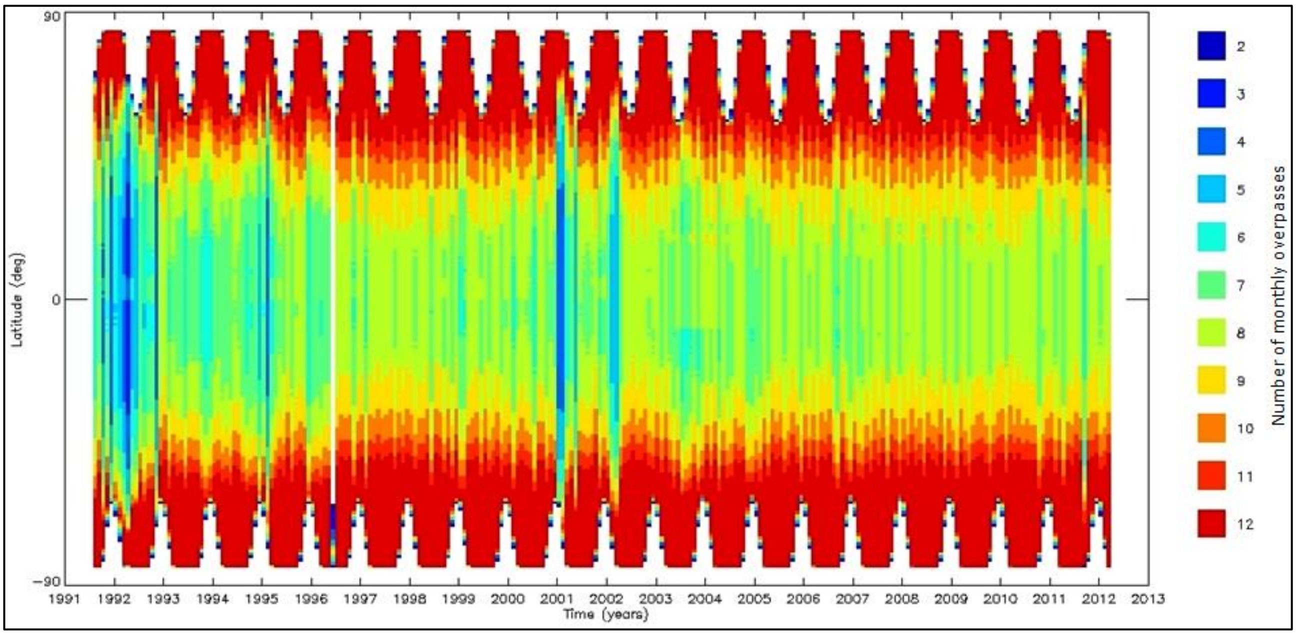


*Figure 2: Time evolution of the ATSR-1/-2 and AATSR zonal mean number of overpasses per month (night-time only).*

## 3. ADVANCED ATSR-WFA DATASET NIGHT-TIME COVERAGE

The monthly record generated by the Advanced ATSR-WFA processing provides the detection date and time, and the pixel's coordinates with a ±1 km geolocation accuracy for each hot spot. The ATSR revisit frequency for night-time measurements is about once every 5 days at equator, rapidly increasing with latitude. The monthly zonal mean of ATSR night-time number of overpasses for the same ground location is shown in Fig.2, where different colours indicate the number of satellite overpasses per month. The monthly record generated by the ATSR-WFA processing provides the detection date and time, and the pixel's coordinates with a±1 km geolocation accuracy for each hot spot.

From Fig.2 it can be deduced that: a) the number of overpasses at each latitude is consistent between the ATSR-1/-2 and AATSR missions [1]; b) only a data gap during June 1996 is present due to ATSR-2 operations (the instrument was turned off during this period). The continuous coverage extends from 65°N to 65°S, while higher latitudes are only covered during local winters: this is due to our choice to analyse top-of-atmosphere (TOA) radiances for which the related solar zenith angle ('SZA') is less than -4°. Only the months with a monthly overpass frequency greater or equal than 6 have been considered in the frame of this intercomparison analysis.

## 4. ALGO3 INTER-COMPARISON WITH MODIS-TERRA FIRE PRODUCTS

In the validation exercise we have compared ALGO3 with MODIS-Terra fire counts for the 2001-2012 time period, therefore the ATSR-WFA night-time fire series has been extended backwards to 1991.

The ALGO3 fire products have been obtained applying two IDL routines:

- Processing: it is in charge of the ingestion of specified parameters of the TOA product using the BEAM library, hot spot detection algorithm and creation of hot spot output ASCII orbit file(s).
- Post-Processing: it is in charge of the hot spot duplication check, monthly statistics, append the classification information (GlobCover), related to the retrieved hot spots, gas flares filtering (time persistency).

The MODIS-Terra fire products used for our inter-comparison are the 'Climate Modelling Grid Fire (MOD14CMH)' freely distributed by NASA [4]. These fire products are gridded statistical summaries of fire pixel information intended for use in regional and global modelling. The products are currently generated at 0.5° spatial resolution for time periods of one calendar month. In order to perform the intercomparison between the two datasets, the ALGO3 night-time fire products have been gridded at 0.5° spatial resolution.

If we consider the swath width and the frequency of the acquisitions respectively (500 km, only night-time for ATSR and 2330 km, day/night-time for MODIS-Terra) we do expect a significant differences in total number of detected hot spots with a scaling factor approximately equal to 9 at the equator, however, differences may depends on fire characteristics.

The ALGO3 (night-time) vs. MODIS-Terra (day + night- time) monthly fire counts comparison plots and the related correlation between the two algorithms over the selected areas of interest from 2001 to 2012 are shown in Fig.3 and Fig.4, where ALGO3 data are in red, MODIS-Terra in blue. It can be deduced that, without applying a scaling factor, except for Central America area an excellent correlation (greater than 90%) between the two algorithms has been observed. The new algorithm ALGO3, based on the detection of the ATSRs 1.6 µm SWIR band reflectance during night-time observations, fully extends the ATSR-WFA time series back to 1991 using the ATSR-1 measurements as shown in Fig. 5.

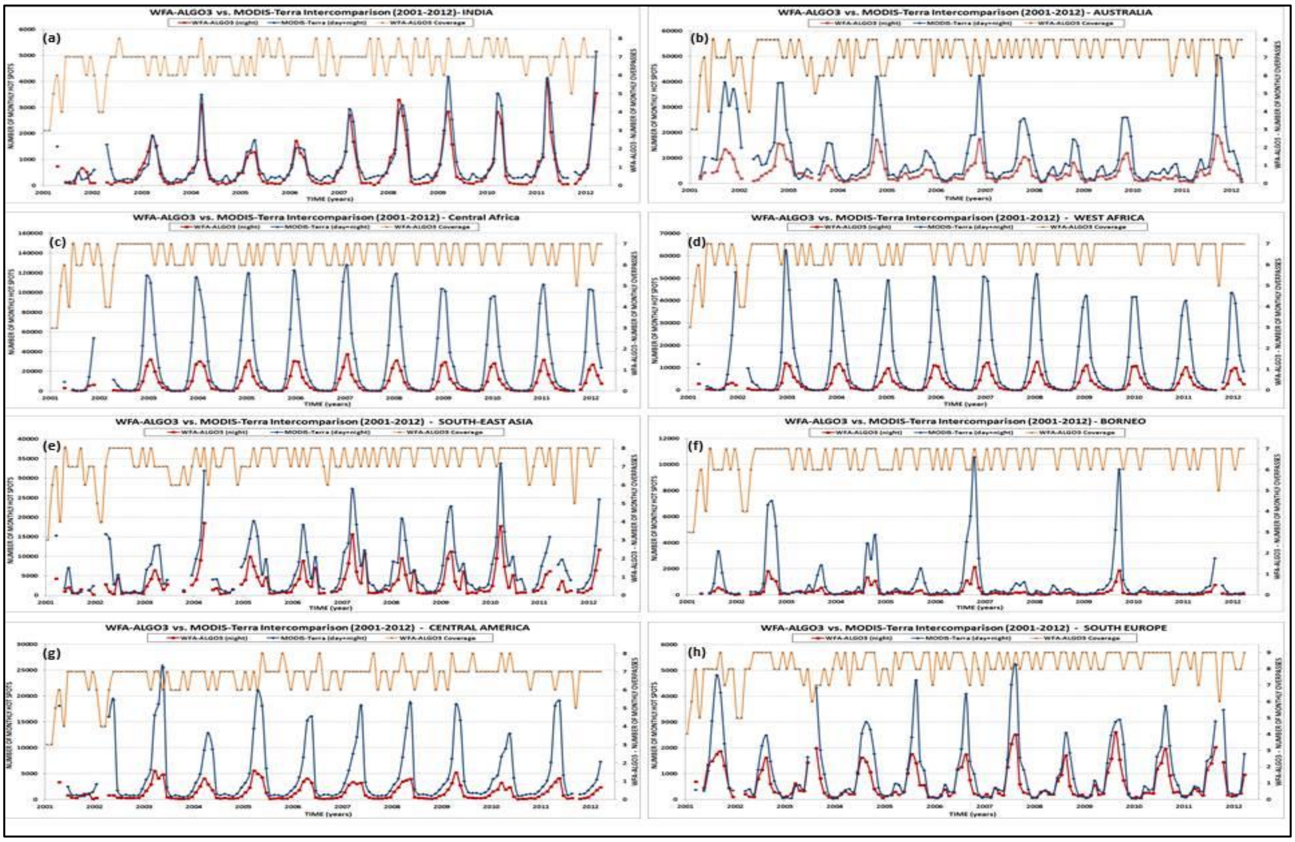


*Figure 3: Comparison, from 2001 to 2012, between ALGO3 (night-time) in red and MODIS-Terra (day+night-time) in blue fire products over: a) India, b) Australia, c) Central Africa, d) West Africa, e) South-East Asia, f) Borneo, g) Central America and h) South Europe.*

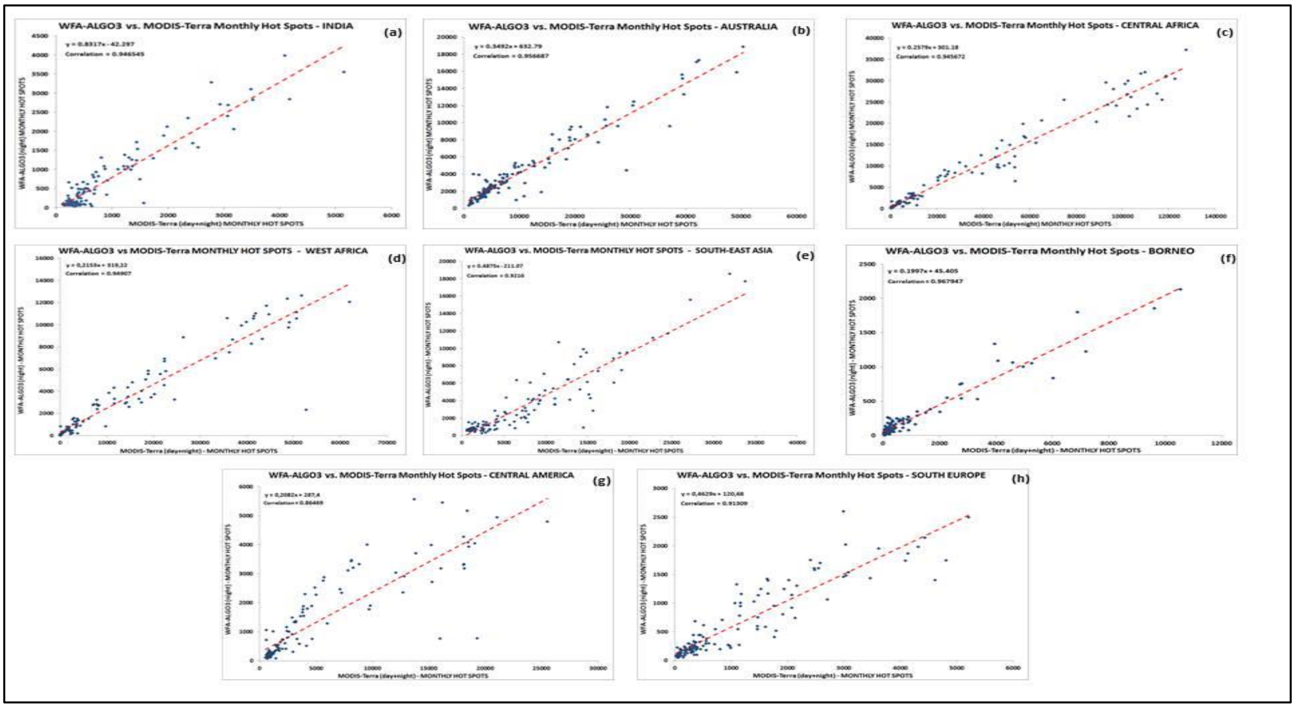


*Figure 4: ALGO3 fire count residuals trend plots over: a) India, b) Australia, c) Central Africa, d) West Africa, e) South-East Asia, f) Borneo, g) Central America and h) South Europe.*

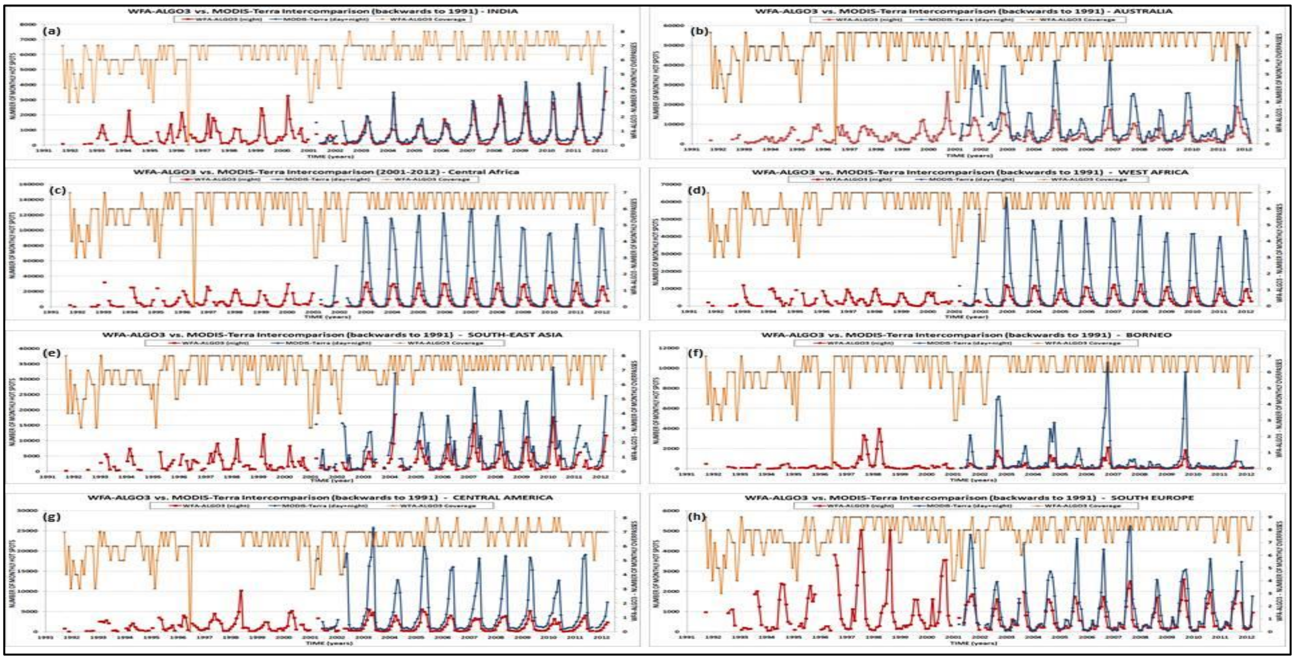


*Figure 5: Comparison, extended backwards to 1991, between ALGO3 (night-time) in red and MODIS-Terra (day+night-time) in blue fire products over: a) India, b) Australia, c) Central Africa, d) West Africa, e) South-East Asia, f) Borneo, g) Central America and h) South Europe.*

## 5. ALGO3 FIRE TRENDS ANALYSIS

For the ALGO3 products a fire trends analysis has been performed over the eight areas of interest. The seasonal components (Fig. 6) have been calculated and removed by applying phase averaging, i.e. removing the average number of fire counts in each calendar month. The resulting residuals are then analysed to detect possible trends by applying the Least Squares Method, requiring a probability level of significance equal to 95% . Fig. 7 and Fig. 8 show, respectively, the residuals trend analysis over 10 years (2001 to 2012) and 21 years (1991-2012) between the two algorithms. Fig. 9 shows the result of the percentage fires trend per year for each test area of WFA-ALGO3 and MODIS-Terra fire products.

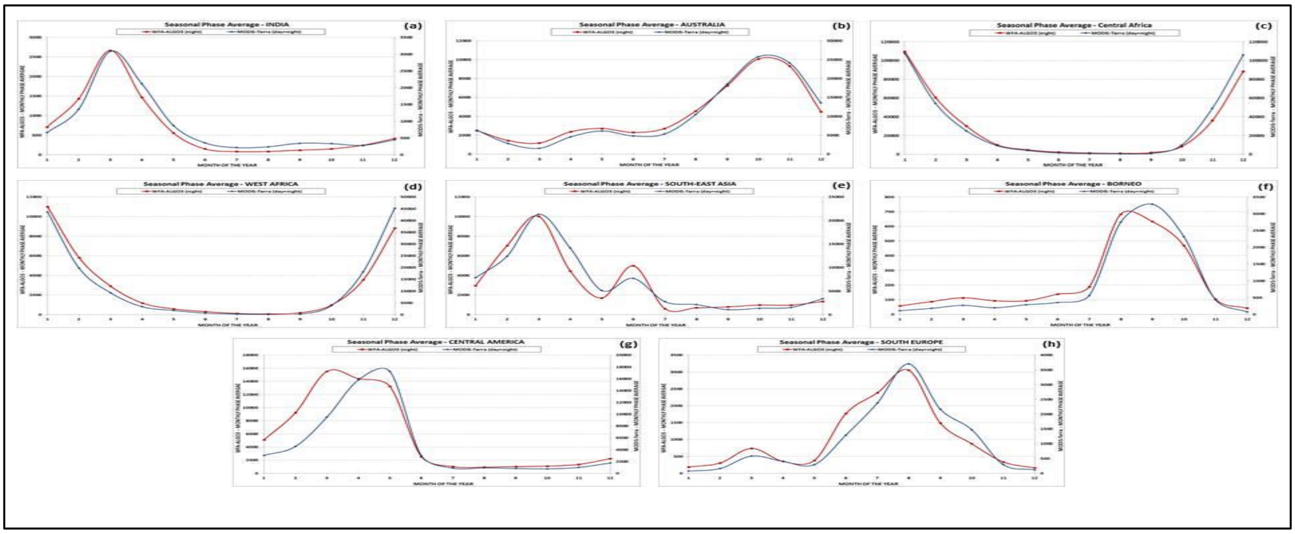


*Figure 6: Seasonal phase average, from 2001 to 2012 between ALGO3 (night-time) in red and MODIS-Terra (day+night-time) in blue fire products over: a) India, b) Australia, c) Central Africa, d) West Africa, e) South-East Asia, f) Borneo, g) Central America and h) South Europe.*

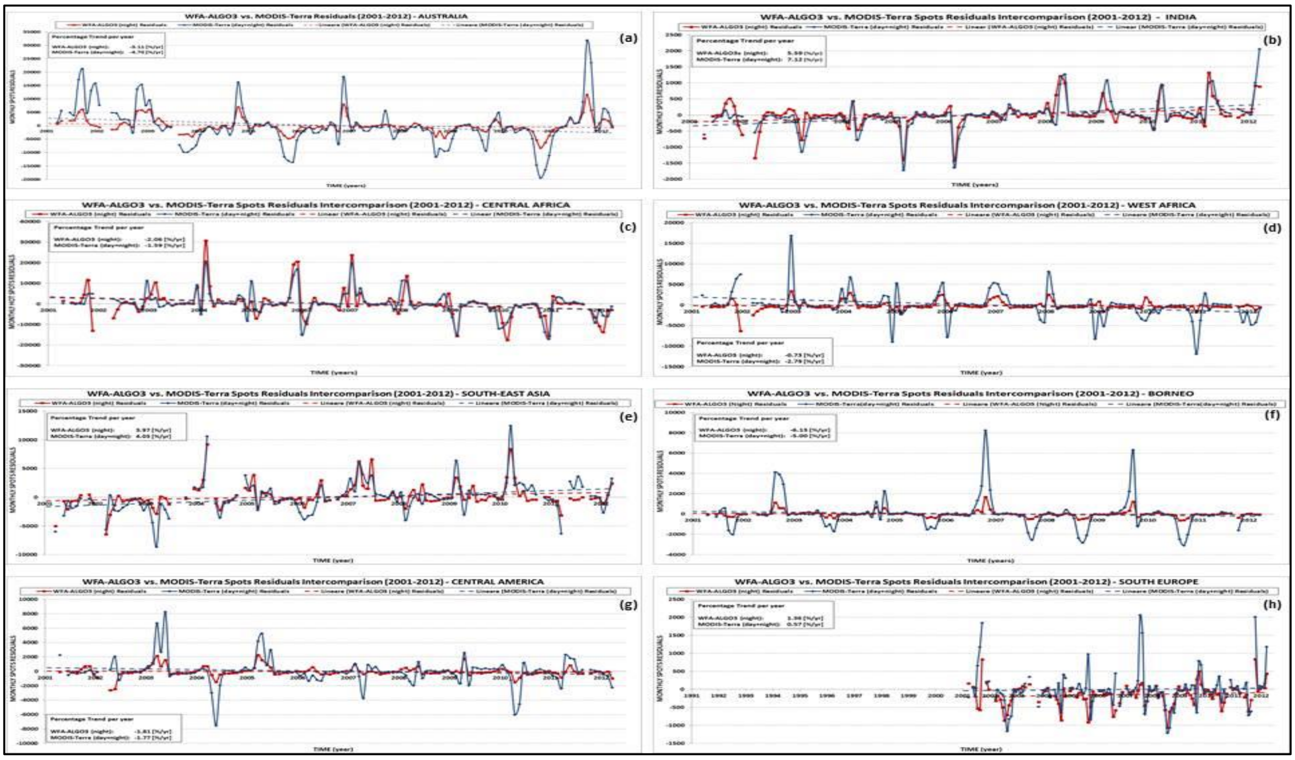


*Figure 7: Residuals trend analysis, from 2001 to 2012 between ALGO3 (night-time) in red and MODIS-Terra (day+night-time) in blue fire products over: a) India, b) Australia, c) Central Africa, d) West Africa, e) South-East Asia, f) Borneo, g) Central America and h) South Europe.*

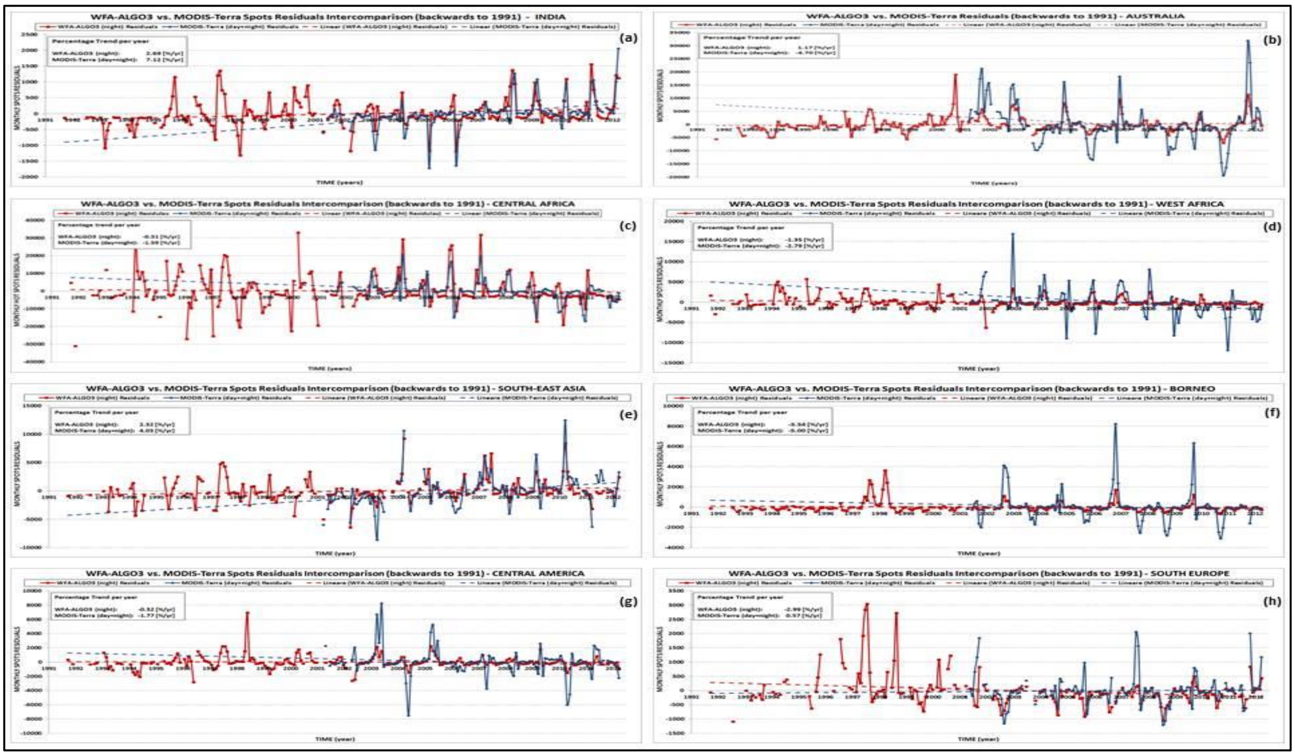


*Figure 8: Residuals trend analysis, extended backwards to 1991 between ALGO3 (night-time) in red and MODIS-Terra (day+night-time) in blue fire products over: a) India, b) Australia, c) Central Africa, d) West Africa, e) South-East Asia, f) Borneo, g) Central America and h) South Europe.*

| Area of Interest | WFA-ALGO3 (night) % Trend per year | MODIS-Terra (day+night) % Trend per year | Monthly Hot Spots Correlation (%) |
|---|---|---|---|
| Australia | -3.11 | -4.7 | 95.67 |
| Central Africa | -2.06 | -1.59 | 94.57 |
| West Africa | -0.73 | -2.79 | 94.91 |
| South Asia | 3.97 | 4.03 | 92.2 |
| India | 5.59 | 7.12 | 94.65 |
| Borneo Area | -6.13 | -5.00 | 96.79 |
| Central America | -1.81 | -1.77 | 86.47 |
| South Europe | 1.36 | 0.57 | 91.31 |

*Accordingly to the Least Squared Method*

Trend Statistically Significant (S/N>1) — Trend Statistically Insignificant (S/N<1)

$$Tr_{\%} = \frac{100 * Tr_0}{Mean_f}$$

$Tr_0$ = *Time series linear trend;* $Mean_f$ = *Time series hot spots mean;* $Tr_{\%}$ = *Percentage trend per year*

*Figure 9: Percentage fires trend per year analysis for each test area of WFA-ALGO3 and MODIS-Terra fire products.*

## 6. CONCLUSION

The importance of ALGO3, based on detection of the ATSRs 1.6 µm SWIR band radiances during night-time observations, relies on the fact that it extends the ATSR World Fire Atlas to 21 years of night-time fire series. Outside the South Atlantic Anomaly, the ALGO3 has the capacity to detect small to large fires and gas flares, overcoming the problems generated by background signal (no false alarms). From the analysis performed it can be deduced that the number of overpasses at each latitude is consistent between the ATSR-1/-2 and AATSR missions, except for an ATSR-2 data gap in June 1996. Except for a scaling factor, the ALGO3 monthly fire counts are in line with the related MODIS-Terra fire products with an high correlation (~93%). Future activities will include the adaptation of the new ATSR-WFA algorithm to the data from SLSTR instrument on board of Sentinel-3 and to the SWIR band of the high resolution satellites (day-time) in order to perform the same analysis on the upcoming Sentinel-2 data.

## 7. ACKNOWLEDGMENTS

The MODIS fire products used for our inter-comparison exercise are the 'Climate Modelling Grid Fire (MOD14CMH)' freely distributed by NASA at http://modis-fire.umd.edu

## 8. REFERENCES

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